

The influence of the several very large solar proton events in years 2000–2003 on the neutral middle atmosphere

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Abstract

Solar proton events (SPEs) are known to have caused changes in constituents in the Earth's polar neutral middle atmosphere. The past four years, 2000–2003, have been replete with SPEs. Huge fluxes of high energy protons entered the Earth's atmosphere in periods lasting 2–3 days in July and November 2000, September and November 2001 and October 2003. The highly energetic protons produce ionizations, excitations, dissociations and dissociative ionizations of the background constituents, which lead to the production of HO_x (H, OH, HO₂) and NO_y (N, NO, NO₂, NO₃, N₂O₅, HNO₃, HO₂NO₂, ClONO₂, BrONO₂). The HO_x increases lead to short-lived ozone decreases in the polar mesosphere and upper stratosphere due to the short lifetimes of the HO_x constituents. Large mesospheric ozone depletions (>70%) due to the HO_x enhancements were observed and modeled as a result of the very large July 2000 SPE. The NO_y increases lead to long-lived stratospheric ozone changes because of the long lifetime of the NO_y family in this region. Polar total ozone depletions >1% were simulated in both hemispheres for extended periods of time (several months) as a result of the NO_y enhancements due to the very large SPEs.

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1. Introduction

Explosions on the Sun sometimes result in large fluxes of high-energy solar protons at the Earth, especially near Solar Maximum. This period of time, wherein the solar proton flux is generally elevated for a few days, is known as a solar proton event (SPE). Solar cycle

23 experienced a large number of extremely energetic SPEs in years 2000–2003. Huge fluxes of high-energy protons occurred in July and November 2000, September and November 2001 and October 2003.

Solar protons are guided by the Earth's magnetic field and impact both the northern and southern polar cap regions (>60° geomagnetic latitude), e.g., see Jackman and McPeters (2004). These protons can impact the neutral middle atmosphere (stratosphere and mesosphere) and produce ionizations, dissociative ionizations and excitations. Both HO_x (H, OH, HO₂) and NO_y (N, NO, NO₂,

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